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(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON [SE/SE]; S–126 25 Stockholm (SE).

(72) Inventors: MALMGREN, Göran; Gösta Ekmans Väg 5, S–129 35 Hägersten (SE). KHUN–JUSH, Jamshid; Maxfeld Strasse 37, D–90409 Nürnberg (DE). LI, Hui; Berliner Platz 12, D–90489 Nürnberg (DE). DETTMAR, Uwe; Sudetenstrasse 22, D–61440 Oberuriel (DE).

(74) Agents: MRAZEK, Werner et al.; Aros Patent AB, P.O. Box 1544, S–751 45 Uppsala (SE).

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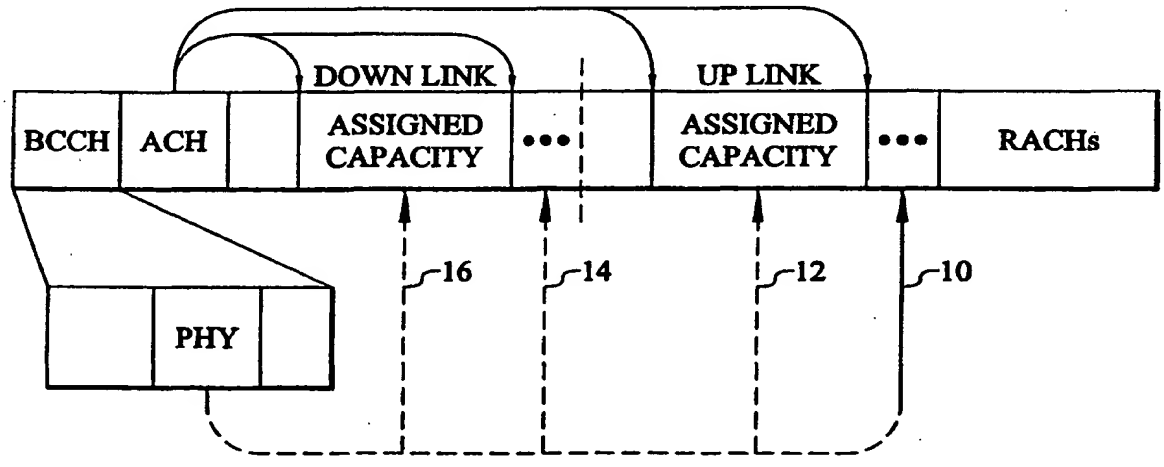

(57) Abstract

A TDMA/TDD link adaptation method determines radio link quality at a base station. The radio link quality is used to update and broadcast a physical layer parameter indicator (10–16) from the base station on a broadcast control channel having a common physical layer parameter indicator for all uplink and downlink channels.

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LINK AND RADIO CELL ADAPTATION IN TDMA/TDD SYSTEMS

TECHNICAL FIELD

The present invention relates generally to TDMA/TDD (Time Division Multiple Access / Time Division Duplex) radio communication systems, and especially to adaptation of the systems to prevailing radio conditions.

BACKGROUND

ETSI BRAN (Broadband Radio Access Network) is developing a short-range high data rate system, HIPERLAN Type 2 (also called H/2), mainly for indoor operation. Some outdoor scenarios are also considered (campus areas, downtown city areas). The target areas are offices, conference halls, exhibition fairs, airports and home environments. The spectrum is unlicensed and thus several "operators" may use the same spectrum. The interference environment may change during operation due to for example new operators in the vicinity of the own network and it is then very difficult to predict what type of interference the system shall be able to handle. The large difference in radio propagation, i.e. LOS (Line Of Sight) and NLOS (No Line Of Sight), and interference environments in which the system be must be able to operate, puts strong requirements on the system that it is able to adapt to its current situation. In this type of systems, one radio cell might be exposed to larger interference than other radio cells. Just an adaptation per radio cell to handle this situation is referred to as "radio cell adaptation". Furthermore, the mobile terminals (MTs) associated with a certain base station (BS) may have different reception qualities in their uplink and downlink respectively. Hence, in this case each MT might want to use different transmission parameters, e.g. code rate (protection level) and modulation alphabet, to be able to adjust its reception quality in the uplink and downlink. This adaptation could be performed per MT or per its individual connections. In the latter case differing traffic and QoS (Quality of

Service) parameters have to be considered. For example, one MT could have a connection carrying video using a powerful FEC (Forward Error Correction) code, whereas a connection for file transfer uses a less strong FEC but with ARQ (Automatic ReQuest for retransmission) capabilities.

Typical reception quality measures are:

retransmission rate (PER, Packet Error Rate),
delay spread (time dispersion),
received signal strength (RSSI),
Signal-to-Interference Ratio (SIR)
Bit Error Rate (BER)

Combinations of these performance measures and others are also possible.

Usually link adaptation is divided into two groups: net rate adaptation and gross rate adaptation.

Net rate adaptation means that the incoming data rate is adjusted to fit into the assigned capacity so that the system can handle a certain link quality, i.e. the user has a fixed assigned capacity over the air, and if the radio quality is poor the incoming data rate is reduced and a more robust transmission mode is used. In case of a good connection a higher incoming data rate can be used.

In gross rate adaptation the incoming data rate is "fixed", i.e. the radio system does not change its incoming traffic due to the radio conditions. Instead the radio system tries to sustain the incoming data rate and to counter the variations in link quality by assigning correspondingly varying capacity over the air interface. Thus, two MT with the same incoming data rate could have been assigned different capacity over the air interface based on their individual connection reception qualities. An extra function might be

needed in this case to guarantee fair utilisation of the total available capacity.

Combination of net and gross rate adaptation is of course also possible.

The present situation with regard to adaptation to varying radio conditions in different radio communication standards may be summarised as follows:

HIPERLAN/2: No proposal exists on a protocol that handles the ability to make radio cell adaptation and/or link (per MT or per connection) adaptations. Still, the proposals on the physical layer allow different code rates and modulation alphabets (MPSK and MQAM signal constellations).

GPRS: The system applies net rate link adaptation (selects channel coding) per mobile terminal, see [1]. For downlink traffic the MT request channel coding via ARQ-ACK/NACK messages through the uplink. The BS is using stolen bits (embedded in the burst structure of GSM) to set the channel code for the downlink. Hence, the MT first decodes these bits to obtain information on which channel decoding it shall use for the rest of the burst. In case unacknowledged mode is applied, the MT sends measurements reports to the BS including an estimation of the BER. This information can then be used by the BS to select channel coding for the downlink bursts.

For the uplink traffic the BS commands the MT to use a certain channel coding. This information is transferred to the MT piggybacked on downlink dedicated control channels, e.g. piggybacked on ARQ-ACK/NACK messages.

A drawback is that in GRPS it is not possible to change channel coding during retransmission phase.

EDGE, EGPRS: These two systems apply net rate link adaptation (select channel coding and modulation alphabet) per mobile terminal. No protocol exists yet. However, the structure and protocol is based on the GPRS

structure and a similar protocol will be utilised. Extensive simulation studies have been performed on the system throughput and can be found in [2].

The problem with changing channel coding during retransmissions is solved by doing re-segmentation. However, the frame structure used in these systems is not suited for a TDD system.

DVB, DAB: Digital Video/Audio Broadcasting uses different code rates and modulation alphabets to be able to extend their coverage regions and to enable the possibility for an broadcaster to select suitable parameters so that both data and the ordinary program can be sent on the allocated bandwidth, see [3]. In the pure broadcast scenario no uplink signalling exists. Recently, an ACTS program called MEMO has been developed for individual services; the ordinary GSM network is used for the uplink signalling. In this case downlink link adaptation is possible. Still no protocol that enables this signalling exists.

IEEE 802.11: A new physical layer standard is now developed for 5 GHz operation, see [4]. The standard is not fixed yet and the system will apply some sort of link adaptation. The proposed solution is assuming that the physical layer is totally independent from the IEEE 802.11 MAC layer. To enable this a convergence layer, called PHY PLCP (Physical Layer Convergence Protocol), is put in between, where primitives are used through SAPs (Service Access Point) to instruct the physical layer to react.

The selected link parameters are performed by the sending unit, i.e. in the downlink the BS selects the parameters and in the uplink the MT selects the parameters. Both BS and MT are making measurements before selecting PHY (PHYsical layer) parameters, e.g. RSSI measurements.

The access scheme is based on CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). This implies that one MAC frame (in IEEE 802.11 this is equal to a MPDU (MAC Protocol Data Unit)) is transmitted between

two peer entities only, i.e. the MAC frame is only between a BS (centrally controlled system) and one MT, or the MAC frame is only between two MTs (Ad-hoc system). The duration of the MAC frame depends on the selected PHY parameter In case of a more robust PHY mode, the length of the PHY frame becomes longer due to higher FEC protection.

This is a gross rate adaptation approach which is not able to consider QoS and fairness between users, i.e. since the transmitting unit is selecting the PHY parameters (used capacity), a user may select a parameter corresponding to a robust PHY mode resulting in larger capacity utilisation even though it is not necessary.

In the current version of the IEEE 802.11 proposal for 5 GHz, measurements needed for the selection of PHY parameters has to be performed by both the BS and the MT.

SUMMARY

An object of the present invention is to provide a spectrum efficient radio link adaptation method and frame structure for a TDMA/TDD radio communication system.

This object is achieved in accordance with the attached claims.

Briefly, the present invention uses the BCCH (Broadcast Control CHannel) to adapt the radio cell to prevailing radio conditions. This provides a very efficient method, since a common physical layer parameter indicator may be used for all radio links. An efficient and more flexible embodiment uses a common physical layer parameter indicator to adapt the uplinks of the radio cell, while the downlinks are individually adapted using physical layer parameter indicators in the ACH (Announcement & assignment CHannel). It

is also possible to let the BCCH indicate the physical layer parameters to be used for decoding of the ACH.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by making reference to the following description taken together with the accompanying drawings, in which:

Fig. 1 is a diagram illustrating a basic frame structure of a TDMA/TDD radio communication system;

Fig. 2 is a diagram illustrating an exemplary embodiment of a frame structure in accordance with the present invention suitable for a TDMA/TDD radio communication system; and

Fig. 3 is a diagram illustrating another exemplary embodiment of a frame structure in accordance with the present invention suitable for a TDMA/TDD radio communication system.

DETAILED DESCRIPTION

The system in accordance with the present invention uses a TDMA/TDD (Time Division Multiple Access/Time Division Duplex) MAC (Media Access Control) frame structure (e.g. H/2 and IEEE 802.11). An example of such a frame structure is depicted in fig. 1. A centrally controlled MAC scheme is assumed, i.e. the BS assigns capacity to the MTs. The assignments could be different between two MAC frames, i.e. one user might be assigned capacity in one MAC frame and in the next MAC frame this user will not be assigned any capacity. In case of ad-hoc operation, one MT could act as the central controller. In fig. 1 assigned capacity for one connection (downlink + uplink) has been indicated, while the dots represent assigned capacity for other connections.

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The MAC frame starts with a Broadcast Control CHannel (BCCH) which contains information that is transmitted over the entire area that a BS covers (radio cell). The assignment of different MTs capacity is transmitted in the ACH (Announcement & assignment CHannel, sometimes referred to as resource grant channel or FCH (Frame Control cHannel)). The whole ACH is not necessarily transmitted over the whole radio cell. In case multi beam antennas are applied, the information that is only concerned to a certain beam is then only transmitted over its corresponding coverage area. Pointers may be applied in the ACH so that a MT that is assigned capacity knows exactly when in the frame it is expected to receive and send data, i.e. in the "Assigned Capacity" regions. Random Access CHannels (RACH) might be located at the end of the frame. A MT may request for capacity in its assigned uplink capacity region or via one random access channel.

The exemplary embodiments of frame structures in accordance with the present invention described below are applicable for both gross and net rate link/radio cell adaptation.

Fig. 2 is a diagram illustrating an exemplary embodiment of a frame structure in accordance with the present invention suitable for a TDMA/TDD radio communication system with centrally controlled assignment of capacity. In this embodiment radio cell adaptation parameters are only transmitted in the BCCH (or some other permanent or temporary "control channel" for broadcasting messages). This embodiment may assume that the BS has all information necessary to make a decision on a single PHY parameter setting (e.g. code rate, modulation alphabet, time slots/frame) without any interaction (no explicit uplink signalling) with the MTs). Statistics of the PER, delay spread, received signal strength, SIR and BER could for example be used in the selection procedure. The measurements could be performed on the traffic and control data PDUs (Protocol Data Units) that are received at the BS. The single PHY parameter setting (which is dynamically varying) could be used for some or all connections, as indicated by the dashed arrows 10, 12, 14 and 16 in fig. 2.

One nice feature of this embodiment is that all PDUs of the same type will have the same size and the assignment of capacity resources becomes easier.

Since a common indicator is used for all links, it is appreciated that the embodiment in fig. 1 implements radio cell adaptation.

Radio cell adaptation could also be performed on uplink only or downlink only. Furthermore, the broadcast message including the common PHY parameter indicator may also be broadcast in other "channels" than the BCCH, for example a dedicated PHY parameter channel.

Fig. 3 is a diagram illustrating another exemplary embodiment of a frame structure in accordance with the present invention suitable for a TDMA/TDD radio communication system. In this embodiment a single PHY mode is used in the uplink for all MTs, as indicated by dashed arrows 10, 12. This is an efficient signalling mechanism in case all MT will have similar reception quality in the uplink. This could for example be accomplished if power control is applied in the uplink, i.e. the BS controls (decides) the MTs power level. However, in this embodiment the downlink is individually assigned via the ACH, as indicated by dashed arrows 18, 20 in fig. 3.

The embodiment of fig. 3 implements a combination of radio cell and individual link adaptation, since all uplinks are adapted in the same way as in the embodiment of fig. 1, while downlinks are individually adapted.

A combination of the embodiments of fig. 2 and 3 is also possible. In such a combination the BCCH (or some other permanent or temporary "control channel" for broadcasting messages) is used to broadcast an indicator of the physical layer parameters that should be used to decode the ACH. The physical layer parameters may be individual or common for several channels,

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In some cases it is not necessary for the MTs to update the BS so frequently. This could be in situations when the radio channel and the interference environment are rather static and do not change. To use the ARQ PDU for this signalling will then create unnecessary overhead. To reduce the amount of signalling, a special signalling message (control channel), in which the information is transferred, could be used. This is a special control channel that is separated from other channels. An initial negotiation could take place between the MT and the BS on how often these messages should be transmitted. The BS could then, for example, assign uplink capacity to the MT on a regular basis. Such an embodiment creates a flexible solution. How the information is transmitted to the BS could also be negotiated, e.g. the approach to use the ARQ messages could of course be one way. Another approach is that all updates of the PHY mode are sent through the RACH. An alternative is to "piggyback" the information on one or several other messages, since this type of information may be represented by very few bits.

It will be understood by those skilled in the art that various modifications and changes may be made to the present invention without departure from the scope thereof, which is defined by the appended claims.

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REFERENCES

[1] Digital cellular telecommunications system (Phase 2+); General Packet Radio Services (GPRS); Mobile Station (MS) – Base Station System (BSS) interface; Radio Link Control/ Medium Access Control (RLC/MAC) protocol (GSM 04.60 proposed version 1.1.0)

[2] Johansson C., de Verdier L., Khan F., "Performance of Different Scheduling Strategies in a Packet Radio System", VTC'98, 1998

[3] Lindberg, A., "Aspects on individual services in a dense cellular broadcasting network", MSc Thesis.

[4] Richard, Hitoshi, Masahiro, Doc: IEEE P802.11-98/74-r4, July 1998

CLAIMS

1. A TDMA/TDD media access control frame structure, **characterized** by a broadcast message having a common dynamically updated physical layer parameter indicator for a plurality of channels.

2. The control frame structure of claim 1, **characterized** by a broadcast message having a common dynamically updated physical layer parameter indicator for a plurality of uplink channels.

3. The control frame structure of claim 1, **characterized** by a broadcast message having a common dynamically updated physical layer parameter indicator for a plurality of downlink channels.

4. The control frame structure of claim 1, **characterized** by a broadcast message having a common dynamically updated physical layer parameter indicator for a plurality of uplink channels and a plurality of downlink channels.

5. The control frame structure of any of the preceding claims, **characterized** by said broadcast message indicating the proper physical layer parameter that is to be used by a receiver to decode an announcement and assignment channel.

6. The control frame structure of claim 2, **characterized** by an announcement and assignment channel having individual dynamically updated physical layer parameter indicators for downlink channels.

7. The control frame structure of claim 6, **characterized** by said broadcast message indicating the proper physical layer parameter that is to be used by a receiver to decode an announcement and assignment channel.

8. The control frame structure of any of the preceding claims, **characterized** by said broadcast message belonging to a broadcast control channel.

9. The control frame structure of any of the preceding claims, **characterized** by a separate control channel for occasional requests of physical layer parameter updates from mobile terminals.

10. A TDMA/TDD link adaptation method, **characterized** by

determining radio link quality at a central controller; and

updating and broadcasting a message including a common physical layer parameter indicator for a plurality of channels from said central controller.

11. The method of claim 10, **characterized** by said message including a common physical layer parameter indicator for a plurality of uplink channels.

12. The method of claim 10, **characterized** by said message including a common physical layer parameter indicator for a plurality of downlink channels.

13. The method of claim 10, **characterized** by said message including a common physical layer parameter indicator for a plurality of uplink channels and a plurality of downlink channels.

14. The method of any of the preceding claims 10-13, **characterized** by said message indicating the proper physical layer parameter that is to be used by a receiver to decode an announcement and assignment channel.

15. The method of claim 11, **characterized** by an announcement and assignment channel for individually and dynamically updating physical layer parameter indicators for downlink channels.

16. The method of claim 15, **characterized** by said message indicating the proper physical layer parameter that is to be used by a receiver to decode an announcement and assignment channel.

17. The method of any of the preceding claims 10-16, **characterized** by said message belonging to a broadcast control channel.

18. The method of any of the preceding claims 10-17, **characterized** by a separate control channel for occasional requests of physical layer parameter updates from mobile terminals.

19. The method of any of claims 10-18, **characterized** by said central controller being a base station.

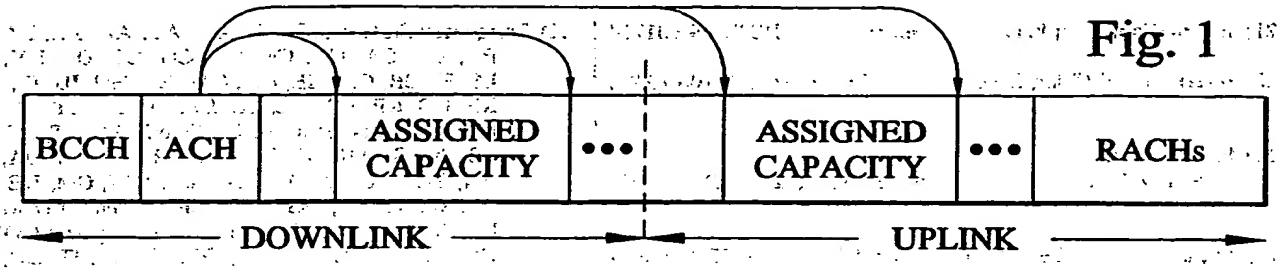

Fig. 1

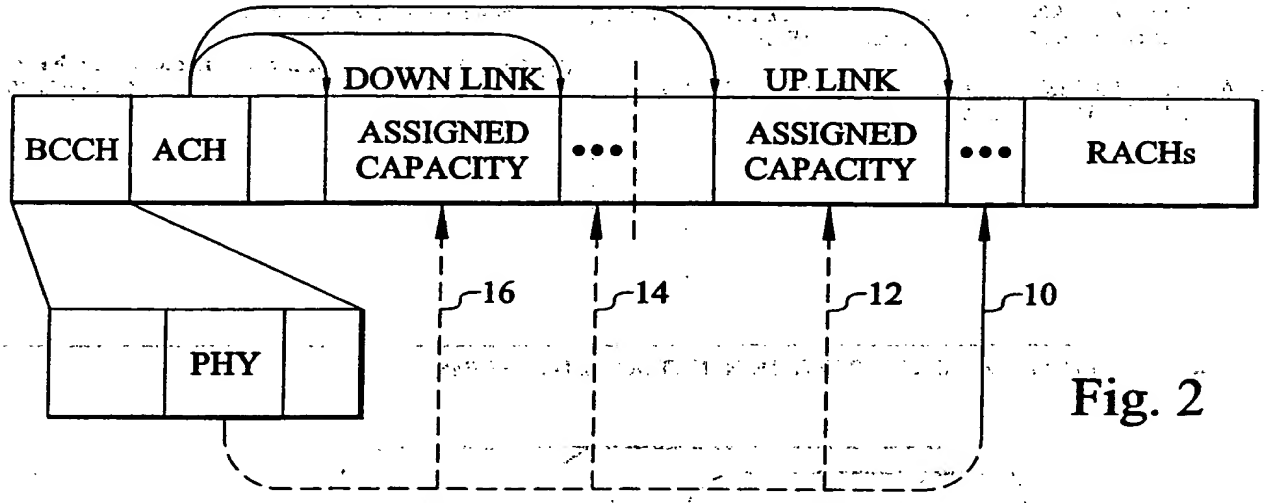

Fig. 2

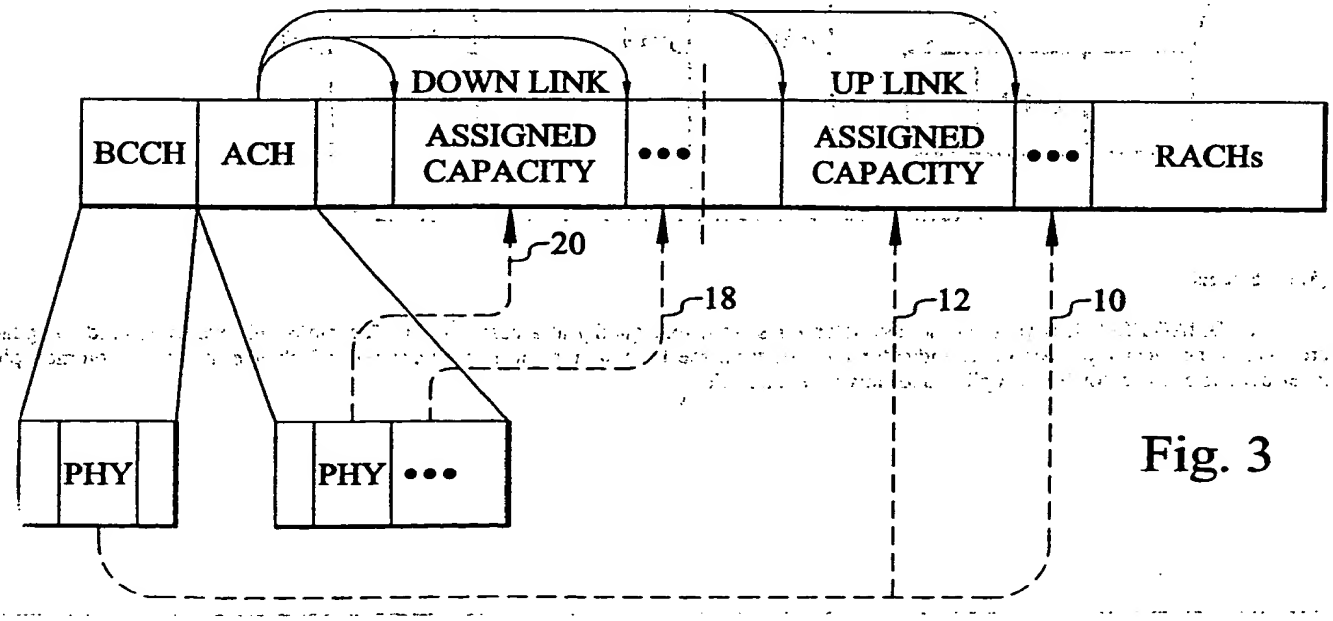

Fig. 3

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(74) Agents: MRAZEK, Werner et al.; Aros Patent AB, P.O. Box 1544, S–751 45 Uppsala (SE).

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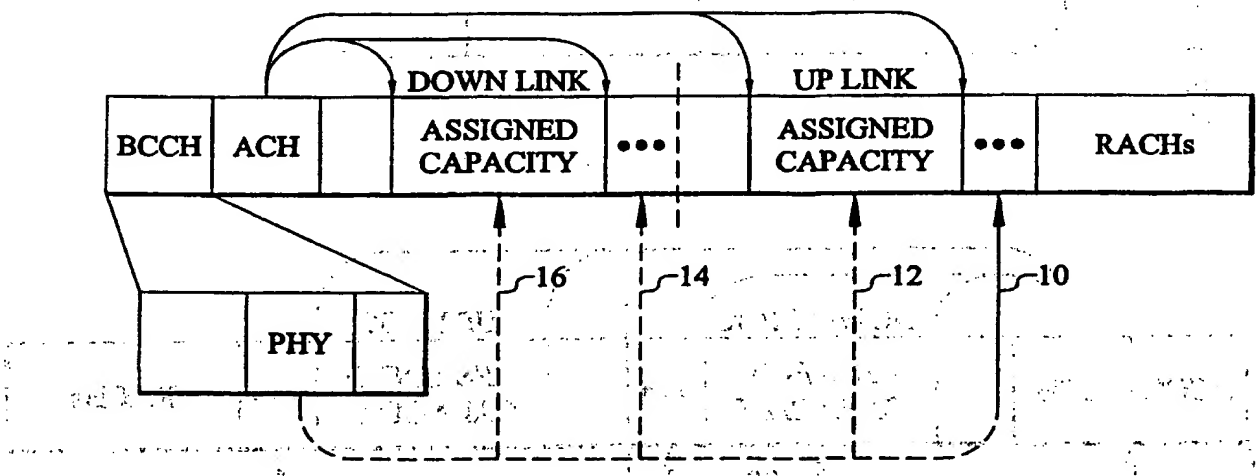

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9832265 A1 (NOKIA TELECOMMUNICATIONS OY), 23 July 1998 (23.07.98), page 5, line 4 - line 30; page 5, line 35 - page 6, line 7; page 6, line 13 - line 37, claim 7	1-4,6,8, 10-13,15, 17-19
A		5,7,14,16
A	WO 9826523 A2 (ERICSSON INC.), 18 June 1998 (18.06.98), page 3, line 32 - page 4, line 2; page 13, line 31 - line 33; page 14, line 18 - page 15, line 7; page 15, line 33 - page 16, line 15	1-19
A	US 5329574 A (NIELSON ET AL), 12 July 1994 (12.07.94), column 3, line 26 - line 53	10

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 March 2000	04 -04- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Peter Göransson / JA A Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01774

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT.

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9907168 A1 (BELLSOUTH CORPORATION), 11 February 1999 (11.02.99), claims 1,2,4, abstract	1,10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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		ZA 9800162 A	09/07/98
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		US 5896376 A	20/04/99
US 5329574 A	12/07/94	NONE	
WO 9907168 A1	11/02/99	AU 8585598 A	22/02/99

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